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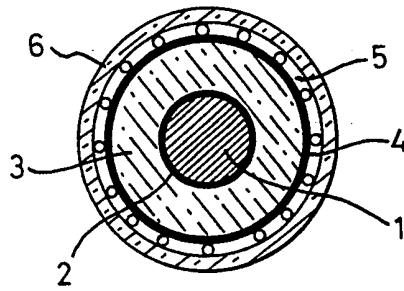
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(54) Medium or high tension electric cable and method of production thereof

(57) The medium and high tension electric cables with which the invention is concerned have an insulation (e.g. of polyethylene, which may be crosslinked), around which is disposed a conductive screening layer. In the prior art, it had been found difficult to make a commercially interesting cable whose screening layer not only gave the desired electrical screening effect, but also remained easy to detach in making terminations etc. during installation. The invention provides an escape from this dilemma by formulating its screening layer composition from a polar monoene (co)polymer (e.g. polybutene or polypropylene), together with an electrically conductive ingredient (e.g. carbon black).

GB 2 000 625 A



## SPECIFICATION

## Medium or high tension electric cable and method of production thereof

5 This invention relates to a medium or high tension electric cable having a conductive layer of extrudable material which is disposed around an insulation consisting of a composition derived from a thermoplastic olefin (co)-polymer or other thermoplastic material, and which serves as an external conductive screening layer.

10 In electric cables which are used for medium and higher tensions, that is to say for voltages above 10 kV, and which have a solid insulation consisting of a thermoplastic material or rubber, it is customary and also necessary to provide electrically conductive layers in the construction of the cable for field limitation purposes. Thus an inner conductive layer, also known as a conductor smoothing layer, is commonly provided around a conductor consisting of a multiplicity of individual wires, and prevents the occurrence of regions of increased field strength resulting from irregularities on the surface of the conductor. A second conductive layer, this being an "external" conductive layer or screening layer is commonly applied around the insulation. In addition to having sufficient conductivity for screening purposes, the external conductive screening layer has to be capable of being removed from the insulation without great effort for the purpose of making terminations, or branch or junction connections, for instance. On the other hand, it is desirable that this external conductive screening layer shall adhere sufficiently firmly to the insulation to enable it to provide full electrical protection for the insulating material lying within it.

45 These apparently conflicting requirements for the "welding" (for electrical purposes) of the external conductive screening layer and the insulation, on the one hand, and for easy stripping, on the other hand, have given considerable difficulty in connection with the selection of materials and manufacturing methods. Certain attempts to extrude a layer of a conductive polyethylene composition around a polyethylene insulation of a high tension cable, for example, have been less than completely successful insofar as, although it was possible to achieve the desired electric protective effect by means of the external conductive screening layer, the latter could be removed from the insulation during installation operations only with difficulty, that is to say only by forceful peeling off.

60 A possible solution to the problem described above has been put forward in US PS 3,876,462. This resorts to chemical modification of the surface of the insulation before the outer conductive screening layer is applied.

65 Because this method entails substantial addi-

tional expense, however, it has hitherto not been commercially successful.

70 It is an object of the present invention, therefore, to provide an electric cable having an insulation consisting of a cross-linked or non-cross-linked thermoplastic material, which is surrounded by an external conductive screening layer in such a manner that electrical protection is ensured, but that on the other hand the conductive screening layer can be detached from the insulation in a simple manner.

75 According to the invention, we provide a medium or high tension electric cable having a conductive layer of extrudable material which is disposed around an insulation consisting of a composition derived from a thermoplastic olefin (co)polymer or other thermoplastic material, and which serves as an external conductive screening layer, characterized in that this conductive screening layer comprises a polybutene, polypropylene, polystyrene or other polar monoene (co)polymer composition having a content of carbon black, graphite or another additive whereby electrical conductivity is conferred upon the composition.

80 In this cable, it can readily be ensured that, although the external conductive screening layer will closely surround the insulation in the desired manner, that is to say in such a manner that for electrical purposes it can be thought of as "welded" thereon, nevertheless for installation purposes the insulation and the conductive screening layer can easily be detached from one another, because no intimate true welding of material takes place between the insulation and the said layer. The objectionable formation of cavities between the insulation and screening layer is avoided, and the said layer can completely fulfil its purpose of screening.

85 In some cases it proves particularly advantageous that the conductive screening layer should comprise a conductive composition of a copolymer of butene, propylene or another polar monoene. By this means the adhesion of the conductive layer may if desired be further improved without impeding its ability to be stripped off.

90 The insulation around which the conductive screening layer is disposed consists, as already indicated, of a composition derived from a thermoplastic material, e.g. an olefin polymer or copolymer. Thus it may for instance comprise cross-linked or non-cross-linked polyethylene. The cross-linking, if required, may be effected by supplying heat after the incorporation of one or more cross-linking agents, or again by grafting one or more silanes or silane compounds on to the polymer molecules and achieving subsequent cross-linking by the action of moisture.

95 The conductive screening layer may be applied around the insulation of the cable by

extrusion; however, it is particularly advantageous for the conductive screening layer to be extruded directly around the insulation while the latter is at an elevated temperature, e.g. before it has cooled to ambient temperature after its own application. It is particularly advantageous in this connection for the average temperatures of the insulation and conductive screening layer to be about 200°C, e.g. 185–215°C. Good "welding" in an electrical sense can be achieved in this manner.

The invention will be explained in greater detail with reference to the accompanying drawing, the single Figure of which is a diagrammatic cross-sectional view showing a high tension cable which is insulated with polyethylene and which constitutes an embodiment of the invention.

The cable shown in the Figure comprises a conductor 1, consisting of a multiplicity of individual wires, covered by an inner conductive layer 2, this being what is called a conductor smoothing layer. The conductor smoothing layer 2, which may for example comprise a conductive (preferably cross-linked) polyethylene composition or a conductive butyl rubber composition, has the function of evening out any irregularities on the surface of the conductor 1, so that regions of increased field strength, which in turn could give rise to glow phenomena, are avoided. An insulation 3 is provided around this inner conductive layer 2, and is composed for example of a moisture-cross-linkable grafted polyethylene which on the one hand has sufficient dielectric strength to withstand the relevant electric stresses and which on the other hand, because of the cross-linking, can also withstand increased temperatures caused for example by short-circuits and other overloads. This insulation 3 is covered by a conductive layer 4 which serves as an electric screening layer, and which, in the embodiment illustrated, comprises a polybutylene or polypropylene composition so formulated as to be conductive; advantageously the layer 4 has a thickness of 0.2 to 0.6 mm. This conductive screening layer 4 is firmly seated on the insulation 3, and for electrical purposes can be considered to be welded to the insulation 3; however, it permits easy installation of the cable, inasmuch as, for the purpose of making a termination or sleeve joint, the two layers 3 and 4 can be separated from one another without difficulty. Armouring 5, consisting for example of metal wires, is applied around the layer 4, and is itself surrounded by an outer sheath 6, which may be of a polyvinyl chloride composition, providing the requisite external mechanical protection.

An extrudable conductive polybutene or polypropylene composition from which the layer 4 in the illustrated embodiment can be formed is advantageously of either of the following formulations:

#### Composition I

100	parts by weight of polybutene;
5–50	parts by weight of carbon black;
70 up to 30	parts by weight of plasticiser, for example atactic polybutene; and
0.1–0.5	parts by weight of stabiliser(s) and/or lubricant(s).

#### 75 Composition II

100	parts by weight of polypropylene;
5–50	parts by weight of carbon black;
80 up to 50	parts by weight of atactic polypropylene; and
0.1–0.5	parts by weight of stabiliser(s) and/or lubricant(s).

However, it is also possible to use a polystyrene composition which has been made conductive by incorporating a suitable proportion of carbon black or graphite.

#### CLAIMS

90 1. A medium or high tension electric cable having a conductive layer of extrudable material which is disposed around an insulation consisting of a composition derived from a thermoplastic olefin (co)polymer or other thermoplastic material, and which serves as an external conductive screening layer, characterized in that this conductive screening layer comprises a polybutene, polypropylene, polystyrene or other polar monoene (co)polymer composition having a content of carbon black, graphite or another additive whereby electrical conductivity is conferred upon the composition.

95 2. A cable according to claim 1, characterized in that the conductive screening layer comprises a conductive composition of a copolymer of butene, propylene, or another polar monoene.

110 3. A cable according to claim 1 or 2, characterized in that the thickness of the conductive screening layer is 0.2 to 0.6 mm.

115 4. A cable according to claim 1, 2 or 3, characterized in that the insulation around which the conductive screening layer is disposed consists of a material cross-linked by the action of moisture.

5. A method of producing a cable according to any preceding claim, characterized in that it includes a step in which the conductive screening layer is extruded directly around the insulation while the latter is at an elevated temperature.

125 6. A method according to claim 5, characterized in that, in the step specified, the average temperatures of the insulation and conductive screening layer are approximately 200°C, e.g. 185–215°C.

130 7. A cable according to claim 1, substantially as described with reference to the accompanying drawing, its conductive screening

layer comprising either Composition I or Composition II.

8. A method according to claim 5, substantially as described with reference to the accompanying drawing, the conductive screening layer being extruded from either

Composition I or Composition II.

9. A cable produced by a method according to claim 5, 6 or 8.

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